ANALYSIS OF CO-FIRING BIOMASS WITH SOUTH AFRICAN COAL IN PULVERISED COAL BOILERS

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ABSTRACT

In this study, the effect on the extent of emissions reduction with co-combustion of small proportions (0-20%) of biomass with coal in a pulverised fuel combustor, is investigated. Such emissions include CO_2, SO_2 and NO_x. South African coal has high ash content and low volatile content that affects its ignitability. The effect of biomass co-firing on ignitability and slagging is also investigated. While higher percentages of biomass could reduce emissions more and improve ignitability, biomass tends to increase the undesirable fouling and slagging propensities, hence limiting the amount of biomass that can be co-fired.

Two types of biomass, namely grass and sawdust (calorific value 16-18 MJ/kg), and one coal (calorific value 21 MJ/kg) were used in this study. Combustion tests were carried out using the Eskom 1 MW Pilot Scale combustion Test Facility (PSCTF). The coal chosen was representative of an average coal burned at the Eskom's coal-fired power stations. For each of the types of biomass, three blends of biomass and coal were used, resulting in seven different feed fuels including coal alone. The ratios of biomass to coal, on an energy basis, in the three blends were 10%:90%, 15%:85% and 20%:80%. Seven tests were also carried out with the same fuels using a drop tube furnace (DTF) to determine the reaction kinetics of the baseline coal and its three different blends with each type of biomass. The reaction parameters obtained from these tests were used as input data in numerical simulations of the tests. Simulation using CFD software was used to predict combustion characteristics of each fuel in the PSCTF, which in turn can be extrapolated to predict the performance in a full scale commercial boiler. The simulation results were validated by the experimental data from the PSCTF; comparison of the combustion and emissions characteristics with experimental data from the PSCTF showed that the simulation procedure was capable of predicting these characteristics with generally good accuracy.

The results coming out of this work are positive. Co-firing with grass at the PSCTF was found to reduce the emissions by between 13% and 50% for NO_X, between 12% and 23% for CO_2 and between 21% and 29% for SO_2 as the proportion of biomass increased from 10% to 20%. The maximum emissions reduction for sawdust occurred at 20% co-firing ratio; these are, 29% for NO_x, 17% for CO_2 and 15% for SO_2.

For grass based co-firing, the combustion efficiency of the coal used was improved by 0.55% and 0.62% for 15% and 20% co-firing ratios respectively; whereas that of sawdust was between 0.78% and 0.38% as co-firing ratio was increased from 10% to 20%. Combustion efficiency for 10% grass dropped by 0.65%. The DTF results indicate that both grass and sawdust were able to improve the ignitability of the coal used in a temperature range of 1000℃ to 1200℃. The combustion efficiency determined from DTF results for this range indicate an improvement of between 0.1% and 1.4% for grass and between 0.8% and 2.45% for sawdust. The QEMSCAN analysis of slag deposits when co-firing biomass indicated that they should generally be weak enough to be handled by soot blowing equipment.

In conclusion grass (herbaceous) biomass resulted in greater emissions reductions than sawdust (ligneous). It was also found that slagging would be less of a problem when using grass, because the slag deposits are more friable than those of sawdust. At higher co-firing ratios grass based co-firing was found to improve coal ignitability better than that can be achieved with sawdust. The optimum co-firing ratio with grass would appear to be about 15% on an energy basis.

This project was carried out to obtain fundamental technical information on some of the salient effects of using biomass co-firing with pulverised power station coal. Before any implementation can be carried out, the next step would be to conduct a detailed technical and economic feasibility study into possible large-scale applications, using full systems engineering principles.